REMARKS

Claims 28, 29, 31 - 44, 46 - 54, 56, and 57 have been cancelled without prejudice, as set forth above. All remaining claims in the application now depend from independent Claim 1.

Applicants' independent Claim 1 has been amended to more precisely claim what applicants regard as their invention. Amended Claim 1 now reads as follows:

1. A method of preheating a metal-containing substrate containing a metal selected from the group consisting of platinum, iridium, ruthenium, and combinations thereof, where said substrate surface is etched at a temperature of at least 150 °C, wherein said method comprises exposing said substrate surface to a preheating plasma generated from a first plasma source gas which includes a slightly reactive gas that is selected so that a compound deposit or residue formed during said preheating is more easily etched during a subsequent pattern etching step than said metal-containing layer, followed by said subsequent pattern etching step carried out using a second plasma source gas which is different from and more reactive with said metal-containing layer than said first plasma source gas.

The amendments to Claim 1 are supported, for example, at page 2, line 25, through page 3, line 4, and page 11, line 1, through page 13, line 3, through page 14, line 11.

Various other claims have been amended for the purpose of maintaining consistency of claim language throughout the entire claim set.

Claim Rejections Under 35 USC § 103

Claims 1 - 57 are rejected under 35 USC § 103(a) as being unpatentable over U.S. Patent No. 6,323,132, to Hwang et al., in view of U.S. Patent No. 6,094,334, to Bedi et al.

Applicants respectfully contend that the Hwang et al. reference and the Bedi et al. reference, either alone or in combination, do not render applicants' claimed invention obvious.

The Hwang et al. reference teaches pre-heating of the substrate using heat transfer from the pedestal underlying the substrate. While the Bedi et al. reference generally describes plasma pre-heating of a substrate, such plasma pre-heating is said to have disadvantages. The Bedi et al. reference does not disclose any particular gases for use in plasma pre-heating of substrates, and there is no mention of using a slightly reactive plasma for preheating, followed by a different, more reactive plasma during etching of the substrate. The focus of the Bedi et al. reference is on the ability of an underlying electrostatic chuck to heat the substrate.

Neither the Hwang et al. reference nor the Bedi et al. reference even suggest the invention claimed by applicants where a metal-containing substrate, containing a metal selected from the group consisting of platinum, iridium, ruthenium, and combinations thereof, is etched at a temperature of at least 150 °C, and wherein the substrate surface is exposed to a preheating plasma generated from a first plasma source gas which includes a slightly reactive gas that is selected so that a compound deposit or residue formed during said preheating is more easily etched during a subsequent pattern etching step than the metal-containing layer which is etched subsequently using a second plasma source gas which is different from and more reactive with the metal-containing layer than the first plasma source gas.

In more detail, U.S. Patent No. 6,323,132, to Hwang et al., teaches a method of etching a platinum electrode layer disposed on a substrate to produce a semiconductor device including a plurality of platinum electrodes. The method comprises heating the substrate to a temperature greater than about 150°C, then etching the platinum electrode layer by employing a plasma of an etchant gas comprising nitrogen and a halogen and a gas selected from the group consisting of a noble gas, BCl_3, HBr, $SiCl_4$, and mixtures thereof. (Abstract) The heating of the substrate to about 150 °C is carried out by heat transfer from a pedestal underlying the substrate.

Referring to Col. 21, line 66, through Col. 22, line 8, of Hwang et al.: ". . . before the platinum electrode layer 16 is etched, the semiconductor substrate 12 supporting the platinum electrode layer 16 is heated to a temperature greater than about 150°C . . . <u>The semiconductor</u>

substrate 12 is heated by the pedestal which supports the wafer 10 during the platinum etching process." There is no mention in Hwang et al. reference cited of plasma heating the substrate. Further, there is no mention or even suggestion about using a lightly reactive plasma to perform the substrate heating, as disclosed and claimed in the present Hwang et al. application.

As discussed above, the present application of Hwang et al. pertains to a method of pre-heating and then etching the surface of a semiconductor substrate where the surface of the substrate is a metal-containing layer, and the metal is selected from the group consisting of platinum, ruthenium, iridium, and combinations thereof, all of which require relatively high temperature etch processing conditions. The pre-heating is carried out using a preheating plasma which is generated from a first plasma source gas which includes a gas which is slightly reactive with the metal in the substrate, where the reactive gas is selected so that a compound deposit or residue which is formed during preheating is more easily etched than the metal-containing layer by a second plasma generated from the second source gas which is used to etch the metal-containing layer. This enables easier removal of the deposits or residues which are inadvertently sputtered onto adjacent surfaces during the ion bombardment which occurs during plasma heating. The deposits or residues are removed during subsequent etching of the metal-containing layer. This technique for ensuring the removal of deposits which are sputtered during plasma preheating is clearly different from any of the subject matter disclosed in the earlier Hwang et al. patent which is cited as a reference.

The Bedi et al. reference discloses an electrostatic chuck for holding a substrate in a process chamber comprising an electrostatic member comprising a polymer covering an electrode, the polymer having a receiving surface for receiving the substrate. A heater abutting the polymer is provided to heat the substrate during processing of the substrate. The heater has a resistance that is sufficiently low to heat the substrate without causing excessive thermal degradation of the polymer. (Abstract) The focus of the disclosure is the ability of the electrostatic chuck to heat the substrate.

Although the Bedi et al. reference discusses the general concept of plasma preheating a substrate at Col. 5, lines 11 - 35, the Bedi et al. reference does not disclose any particular gases for use in plasma substrate preheating. Further, at Col. 5, lines 12 - 17, Bedi et al. teaches "Generally, a plasma heats up a substrate 25 because of the energetic impingement of charged and neutral plasma species onto the surface of the substrate 25. While the energy of the plasma can be increased to increase the temperature of the substrate 25, it is not always desirable to do this, because highly energetic plasma species often provide different etching characteristics than low energy plasma species. This it is preferred to change the temperature of the substrate using a heater 130 . . .". Most importantly, there is no mention of using a slightly reactive plasma for the preheating so that residue sputtered during the preheating step can be subsequently removed during subsequent etching of the substrate with a more reactive etchant plasma, as described and claimed by applicants.

Referring to page 7, lines 15 - 24, of applicants' originally filed Specification: "Ion bombardment heating of a substrate which leads to sputtering/etching of an exposed layer which is to be etched is possible without affecting the critical dimension of the etched feature <u>**if** the plasma source gas used for heating enables the subsequent removal of substantially all of the sputtered/etched material generated during the preheating step</u>. The sputtered/etched residue from preheating is removed during the etch step which follows the preheating of a substrate, for example. To enable removal of a preheating sputtered/etched material residue, <u>the plasma source gas used to generate the preheating plasma may provide a plasma which is slightly reactive with at least the exposed layer to be subsequently etched</u>." "This inventive method provides a relatively quick way of <u>heating</u> a substrate <u>without using a resistance heater in an electrostatic chuck</u>, thereby avoiding the added cost of such equipment and the undesired effects when needing to cool the substrate. Further, <u>this inventive method is not focused on eliminating the sputtering of material during a substrate preheating step, but rather is focused on removing the</u>

material that is sputtered during the preheating step during the pattern etching step."
(Specification Page 8, lines 21 - 26.)

Even if one were to combine the teachings of Hwang et al. with those of Bedi et al., one would not arrive at applicants' claimed invention, because neither Hwang et al. nor Bedi et al. teaches or even suggests pre-heating of a substrate using a plasma which is generated from a first plasma source gas which includes a gas which produces species which are slightly reactive with the substrate to be etched, so that a compound deposit or residue formed during preheating is more easily etched during a subsequent pattern etching step where a different, more reactive plasma is used to pattern etch the substrate.

Whether taken alone or in combination, neither Hwang et al. nor Bedi et al. teaches or even suggests applicants' claimed invention. In light of the above distinctions, applicants respectfully request withdrawal of the rejection of Claims 1 - 57 under 35 USC § 103(a) over Hwang et al., in view of Bedi et al.

Applicants have submitted a Supplemental Information Disclosure Statement which includes various references which were cited by the Examiner during the prosecution of applicants' related application, U.S. Serial No. 09/747,652, which has been allowed. Applicants would like to take this opportunity to distinguish the subject matter claimed herein from those references.

U.S. Patent No. 6,261,967, to Athavale et al., teaches a method for forming a patterned shape from a noble metal. The method includes forming a noble metal layer over a dielectric layer and patterning a hard mask layer on the noble metal layer. Plasma etching is performed on the noble metal layer in accordance with the patterned hard mask layer. (Abstract)

Athavale et al. discloses the simultaneous plasma heating of a substrate while etching a film on that substrate. According to the method disclosed in Athavale et al., plasma heating of

the substrate takes place during etching of a film on that substrate. Athavale et al. does not teach or even suggest the preheating of a substrate to a temperature of at least 150°C using ion bombardment of the substrate by a first plasma composition prior to etching of the substrate by a second plasma composition which removes deposits created by the preheating activity.

The Athavale et al. reference does describe a two-step etching process, but this is with respect to a main etch step and an overetch step. Col. 6, lines 25 - 42, of Athavale et al. teaches as follows: "In another embodiment, a multi-step etching process including a main etch step and an over etch step may be employed. In yet another embodiment, the main etching process step is continued until the complete removal of material 109 is achieved in desired areas. Referring to FIG. 11, in another embodiment, a main etching process step, in which the wafer temperature is lower, preferably between 275 °C and 350 C, is employed to partially etch electrode material 109, leaving behind, preferably between about 5% to about 20% of the initial thickness of electrode material 109 in etched areas. Then, another etching process step, employing a higher wafer temperature, preferably between 350 C. and 450. C is used to remove the remaining thickness of electrode material 109 in the etched areas. Increasing the temperature improves selectivity for the removal of material 109 from layer 105 or layer 107." Thus, the change in the process is one of changing the etch temperature and not the etchant plasma composition, and there is no mention of a plasma preheating step. The Athavale et al. disclosure does not teach or even suggest applicants' claimed invention. Even if one were to combine the disclosure of Athavale et al. with that of Hwang et al., one still would not arrive at applicants' claimed method, because neither Hwang et al. nor Athavale et al. teach the basic elements of applicants' invention and there is no suggestion in the subject matter of these references which would direct one skilled in the art to applicants' invention.

Like the patent to Athavale et al., U.S. Publication No. 2001/0053610A1, of Athavale et al., teaches the simultaneous plasma heating of a substrate while etching a film on that substrate. Paragraph 27 on page 2 of Athavale et al. states as follows: "The present invention provides a

method to plasma etch films of platinum, iridium and other similar materials by using the plasma to heat the wafer to elevated temperatures (e.g., above 200 °C.) and to simultaneously etch the film using halogen including reactive gas mixtures, without using a high temperature (above 200 °C.) wafer electrode. . . The present invention employs the plasma to simultaneously perform (a) heating of the wafer to an elevated temperature (e.g., greater than about 200 °C.) and (b) dry/plasma etching of the thin film material."

The focus of the main invention described in the Ye et al. reference is a method of etching a pattern in a copper layer without corroding the copper pattern itself. As a part of the research carried out, the inventors developed a method of pre-heating the surface of the substrate by ion bombardment from a plasma upon the substrate surface. It is this pre-heating of the substrate using ion bombardment which is claimed in a divisional application which issued as U.S. Patent No. 6,547,978. The Ye et al. disclosure regarding plasma heating of the substrate discusses the use of argon, nitrogen, or helium, to produce a plasma which is used to ion bombard the substrate. With reference to Figure 9, the description at Col. 3, lines 4 - 27 indicates that argon is the preferred pre-heating gas because it provides a more rapid heating rate. There is no mention in the Ye et al. reference of any problem regarding sputtering of the substrate during the pre-heating process and no mention of the creation of fences and other deposits which affect the etch profile obtained during subsequent etching of the copper substrate. This may be because copper is far more reactive than the noble metals which are being etched by applicants and because the copper etch byproducts are far more volatile than the noble metal etch byproducts. In any case, the Ye et al. reference does not describe the problem addressed by applicants and does not suggest any means of solving the problem.

There is nothing in the Ye et al. disclosure which even suggests exposing the copper substrate to a preheating plasma generated from a first plasma source gas which includes a

slightly reactive gas. The disclosure of Ye et al. describes the use of non-reactive, non-corrosive gases to create the pre-heating plasma.

Applicants contend that none of the references provided in the Supplemental Information Disclosure alone or in combination teach or even suggest applicants' invention.

Applicants believe that all presently pending claims are in condition for allowance, and the Examiner is respectfully requested to enter the requested amendments and to pass the application to allowance.

The Examiner is invited to contact applicants' attorney with any questions or suggestions, at the telephone number provided below.

Respectfully Submitted,

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